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Shim et al.

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(54) **PLASMA DISPLAY PANEL**

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(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H01J 17/49 (2006.01)

(52) **U.S. Cl.** **313/582**

(58) **Field of Classification Search** 313/582, 313/584

See application file for complete search history.

(56) **References Cited**

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* cited by examiner

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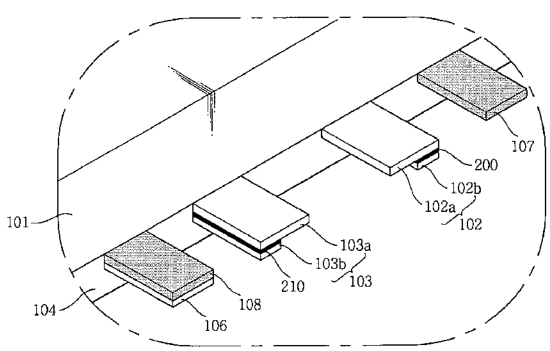
(74) *Attorney, Agent, or Firm*—Ked & Associates, LLP

(57) **ABSTRACT**

A plasma display panel is provided. The plasma display panel includes a front substrate, scan electrodes and sustain electrodes that are positioned on the front substrate substantially parallel to each other, a rear substrate opposite the front substrate, a barrier rib on the rear substrate, and a black layer opposite the barrier rib. The black layer is positioned on the front substrate substantially parallel to the scan electrode and the sustain electrode. The black layer includes a first black layer between two adjacent scan electrodes and a second black layer between two adjacent sustain electrodes. An auxiliary electrode is positioned on the second black layer.

20 Claims, 20 Drawing Sheets



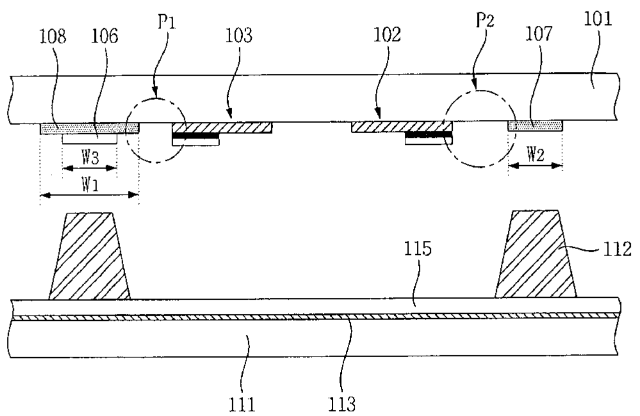


FIG. 1

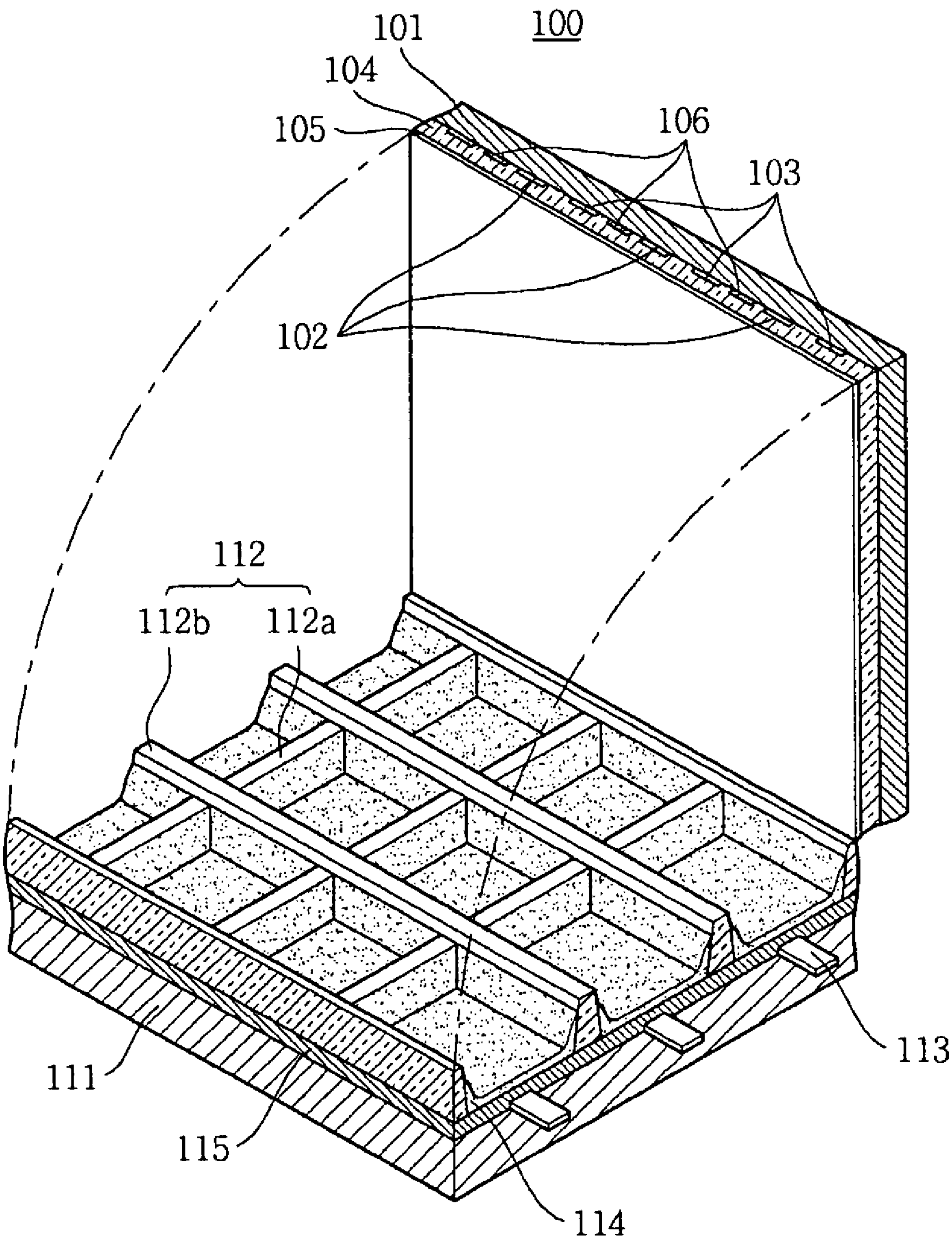


FIG. 2

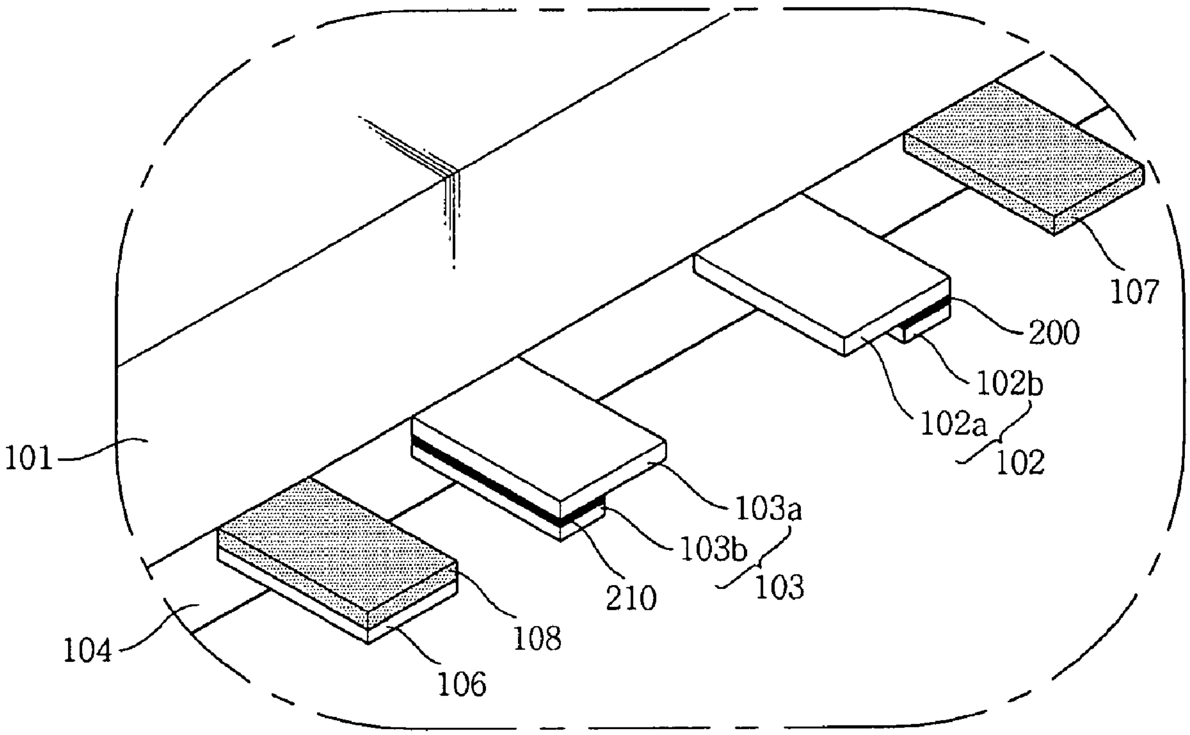


FIG. 3

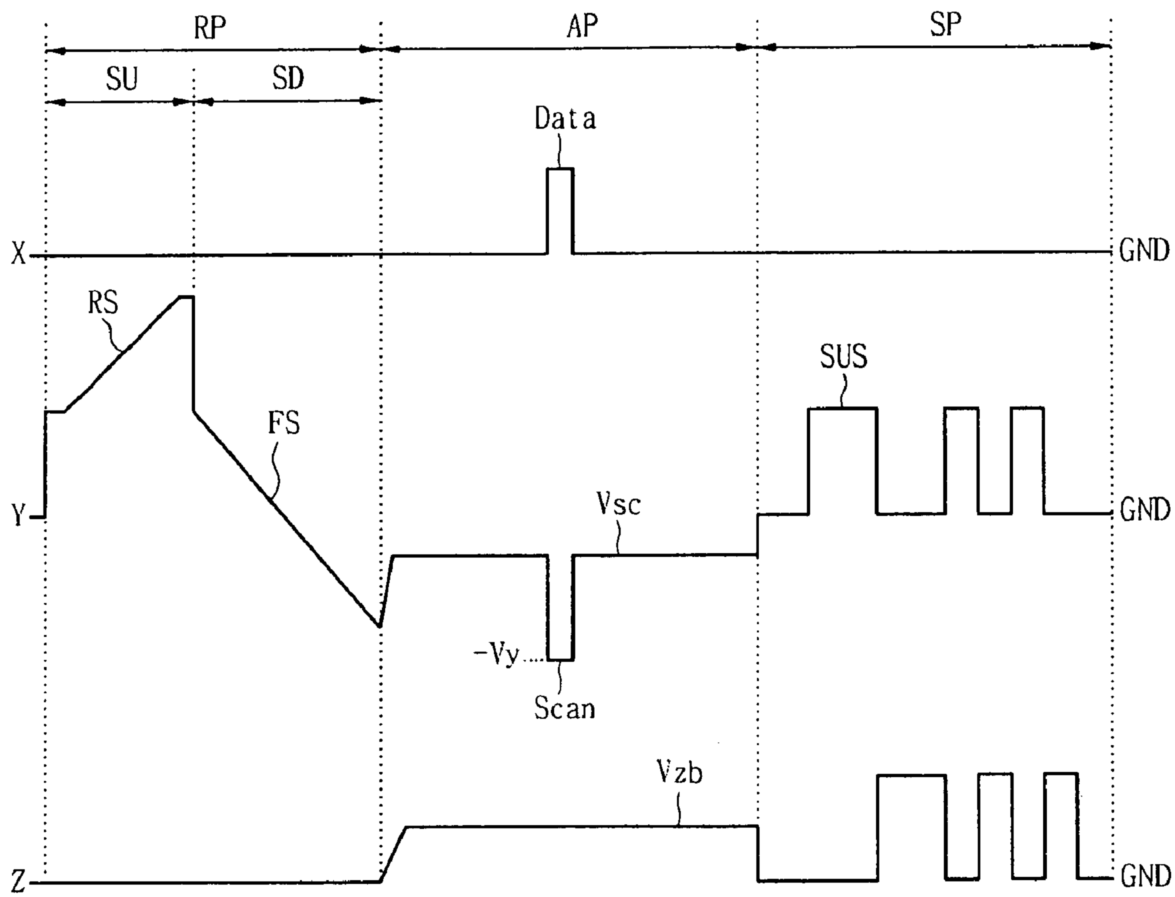


FIG. 4

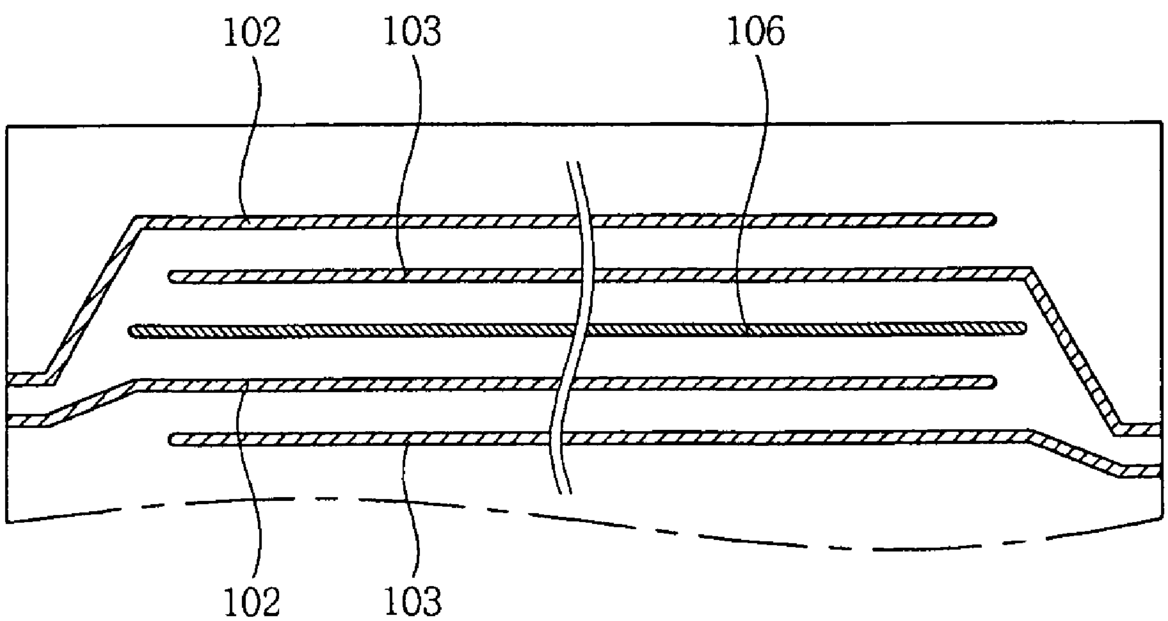
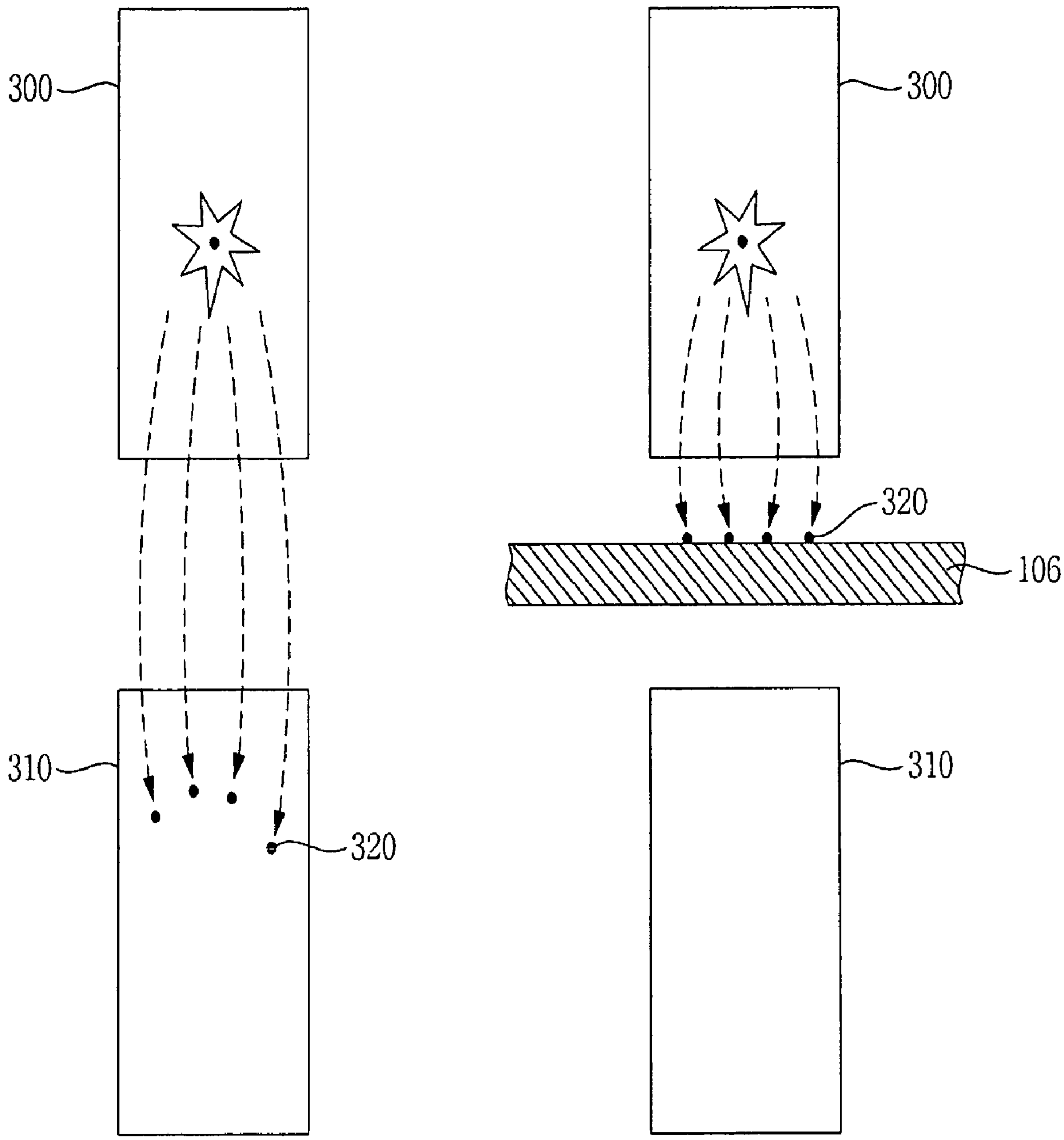


FIG. 5



(a) (b)

FIG. 6

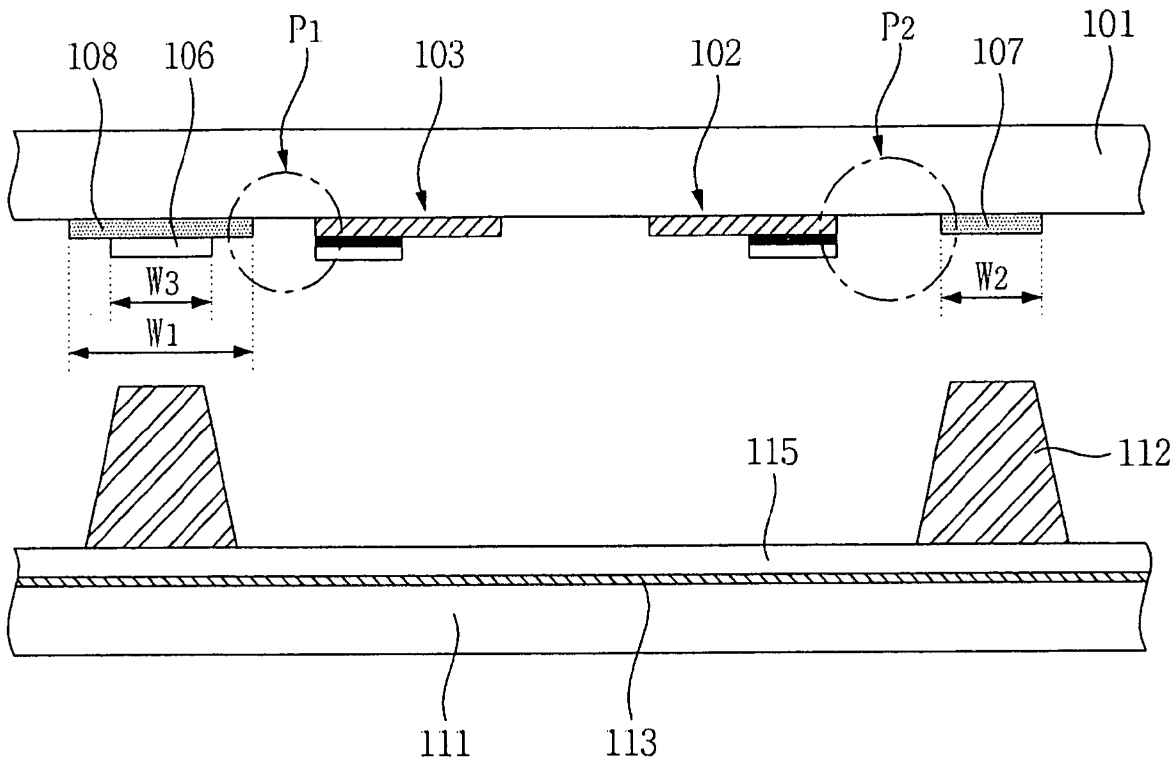


FIG. 7

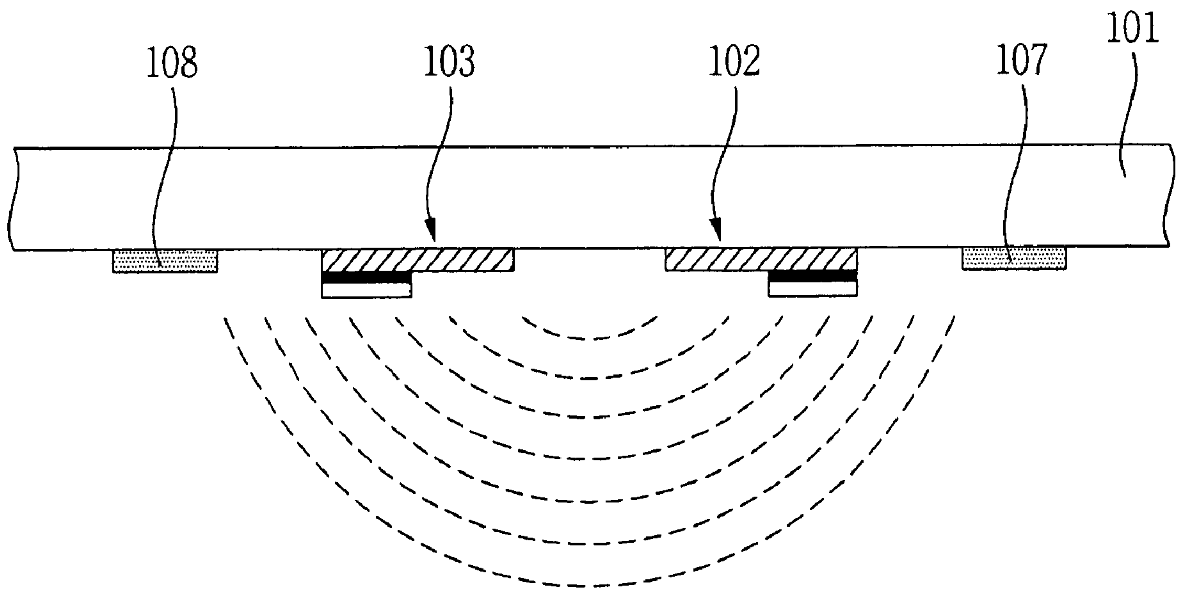


FIG. 8

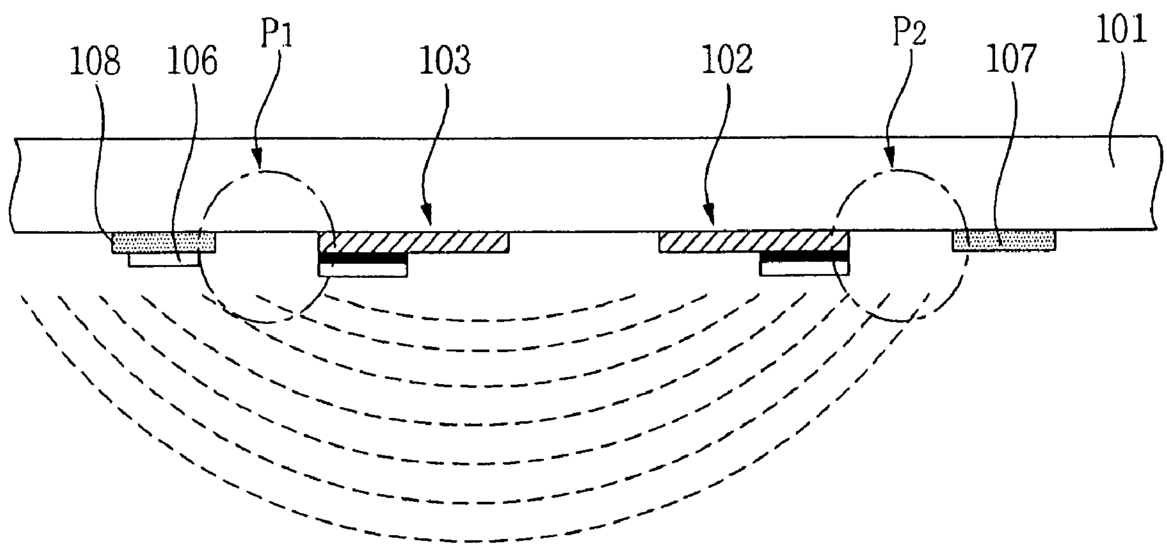


FIG. 9

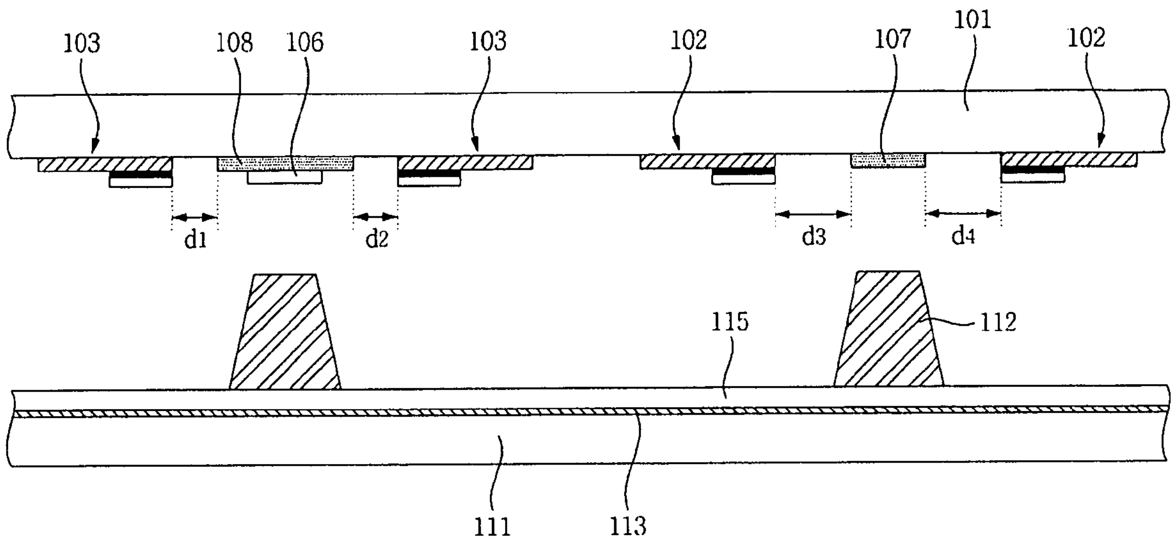

103
108
106
103
102
107
101
102
d1
d2
d3
d4
115
112
111
113

FIG. 10

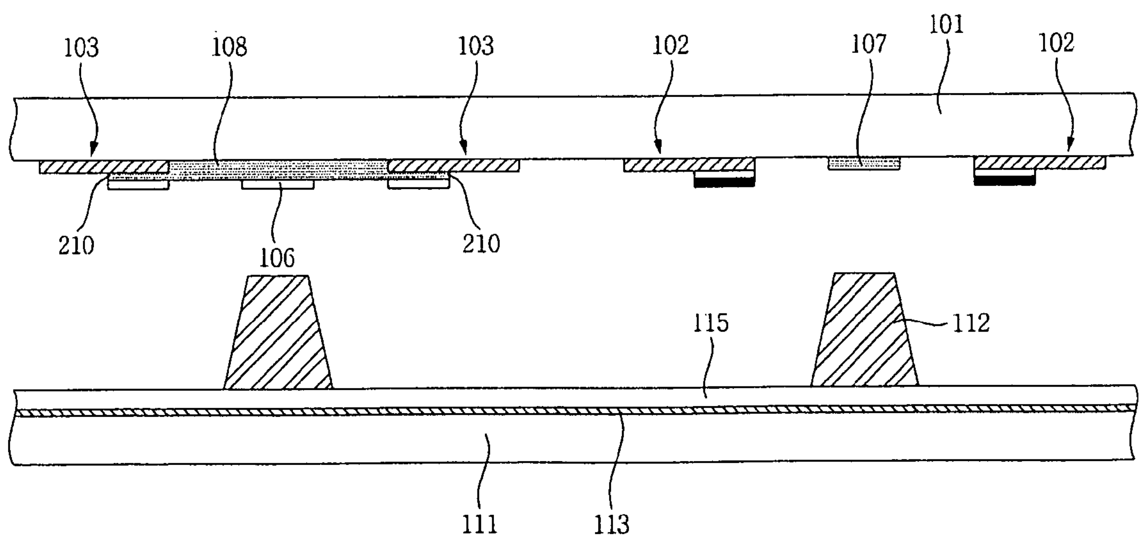

103
108
103
102
107
101
102
210
106
210
115
112
111
113

FIG. 11

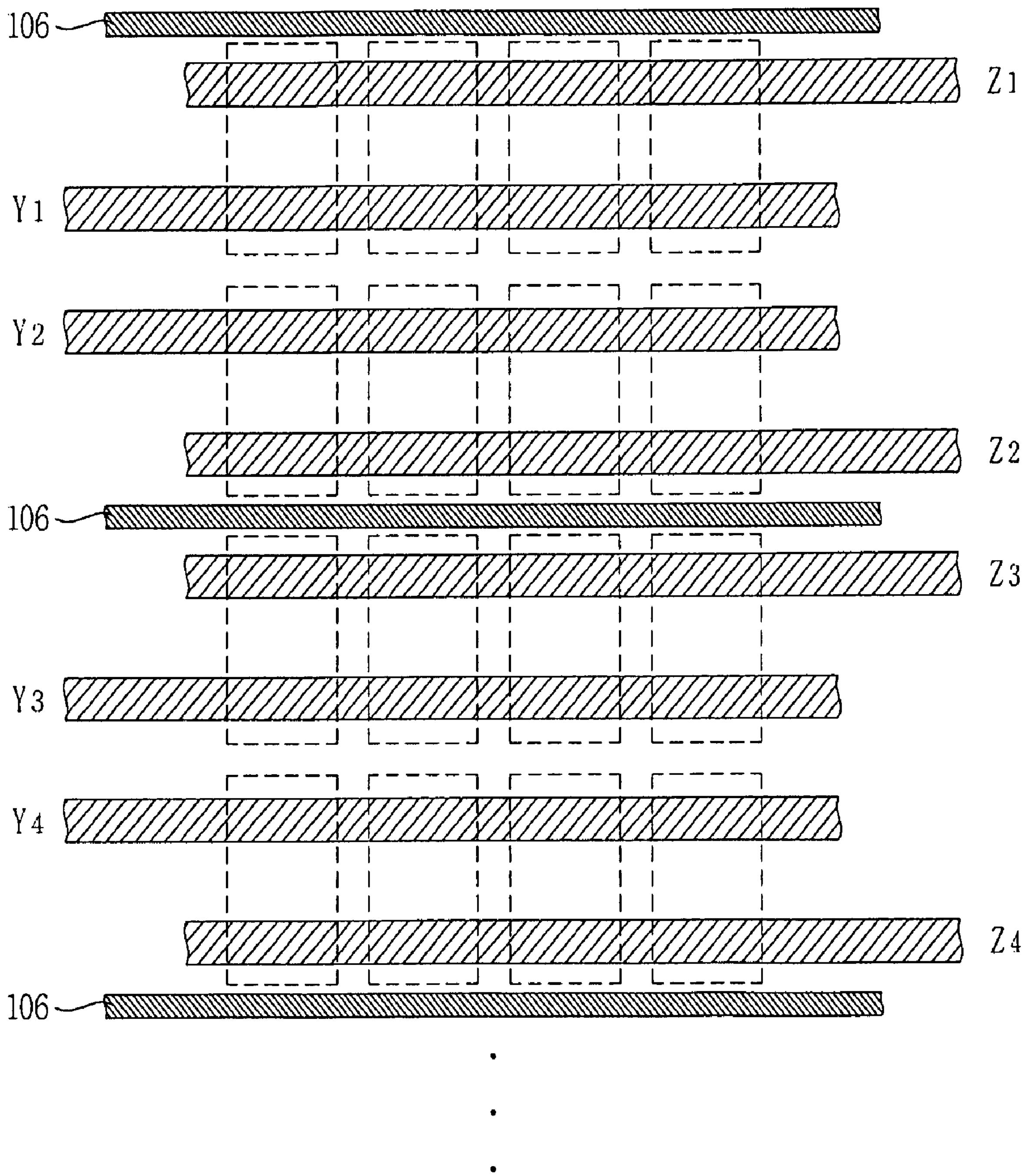


FIG. 12

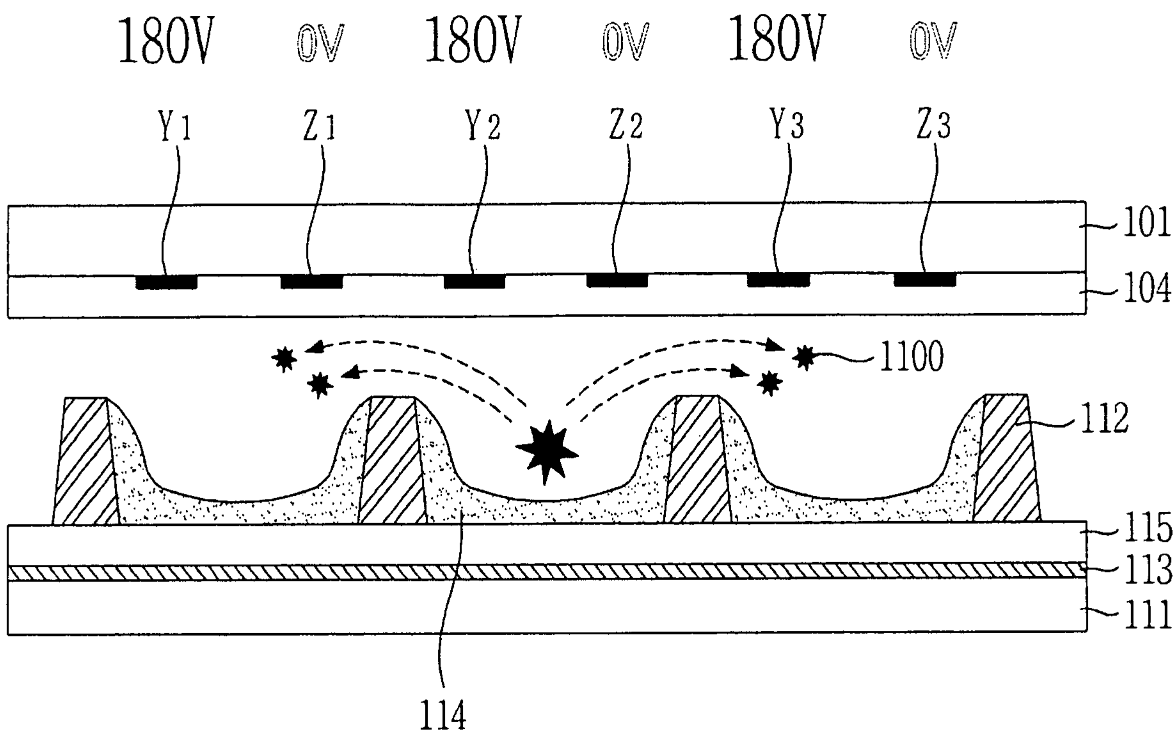

180V
0V
180V
0V
180V
0V
Y1
Z1
Y2
Z2
Y3
Z3
101
104
1100
112
115
113
111
114

FIG. 13

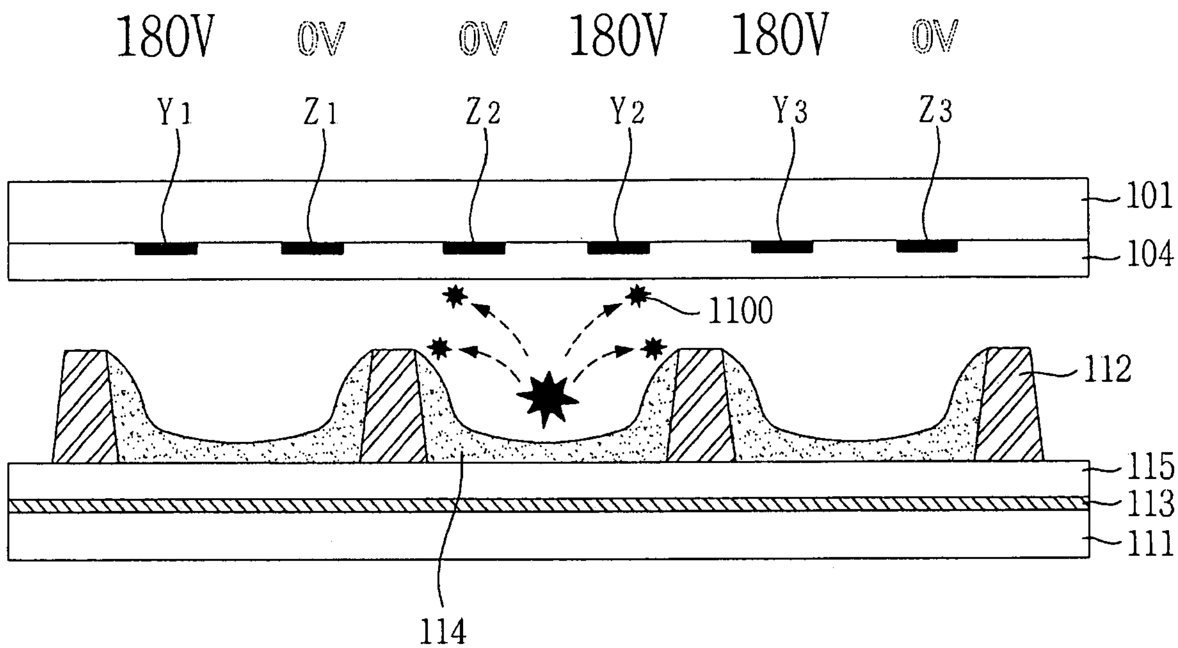

180V
0V
0V
180V
180V
0V
Y1
Z1
Z2
Y2
Y3
Z3
101
104
1100
112
115
113
111
114

FIG. 14

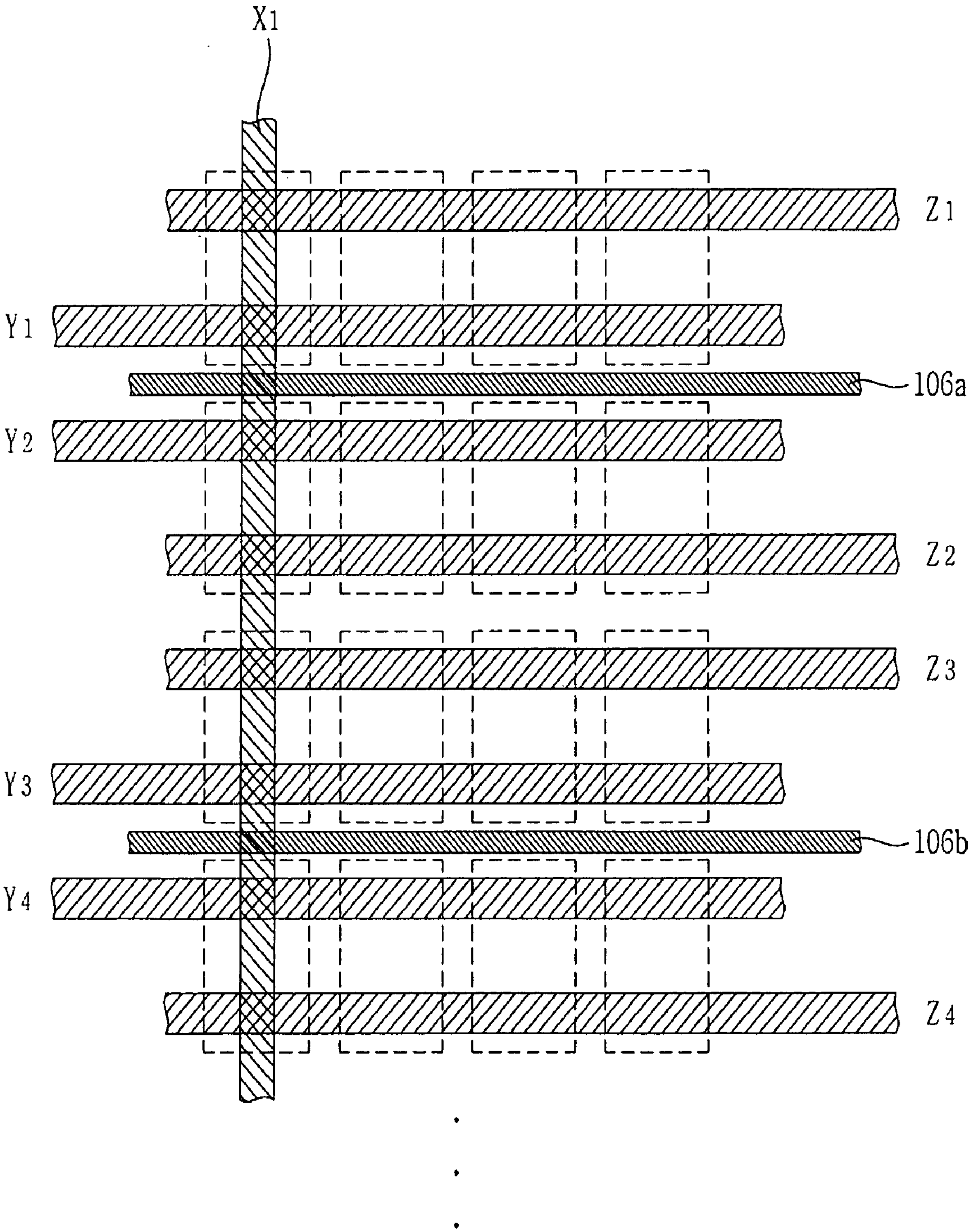


FIG. 15

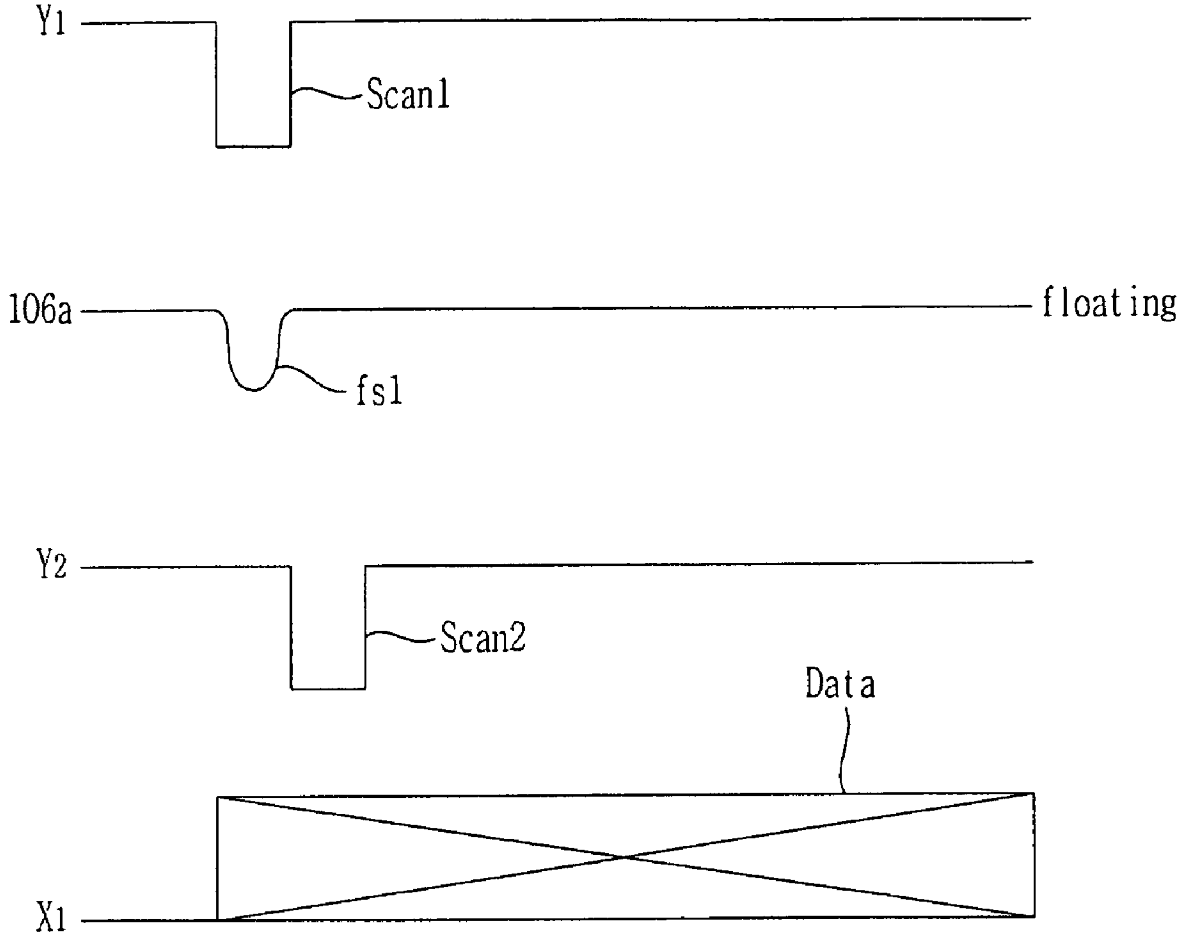


FIG. 16

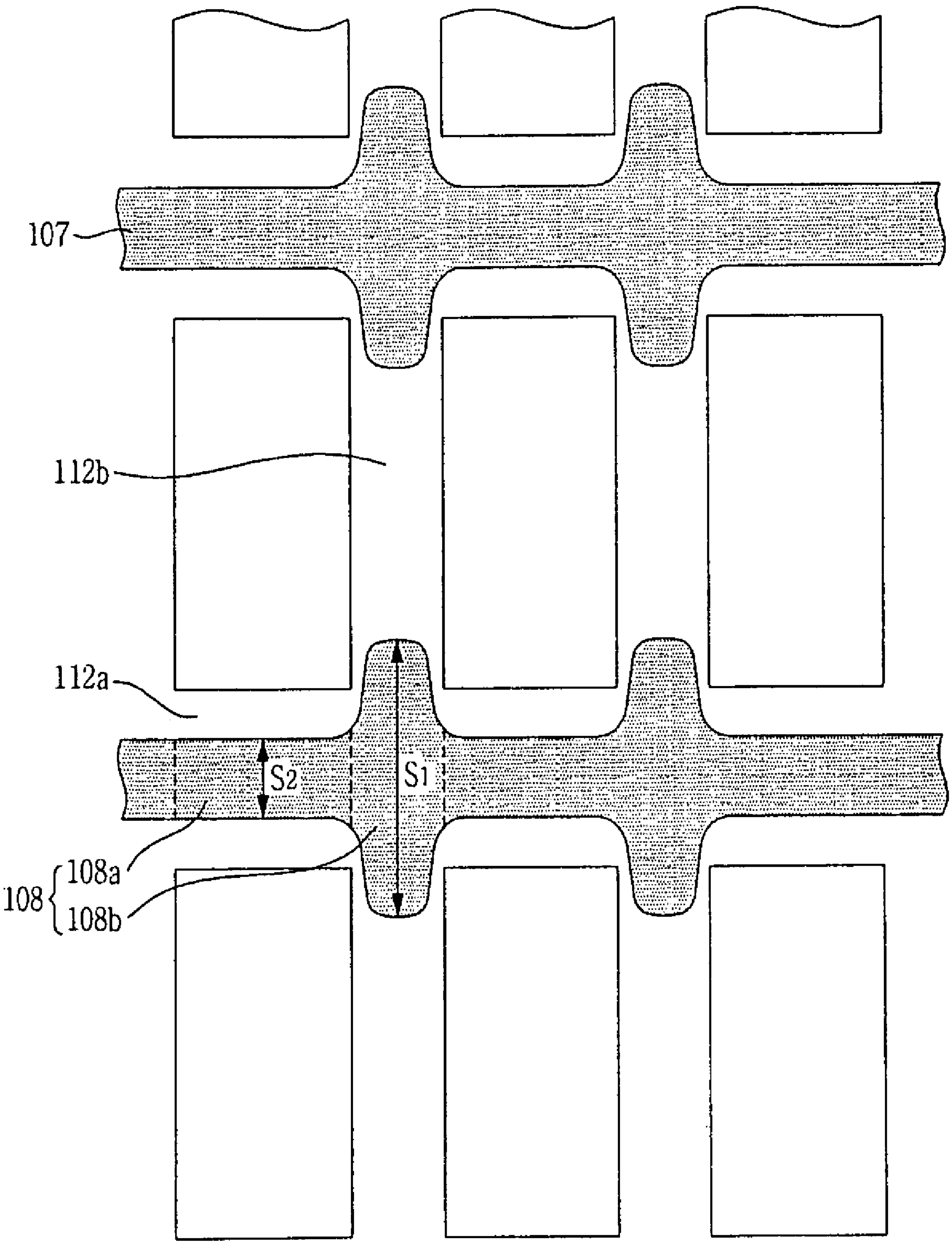


FIG. 17

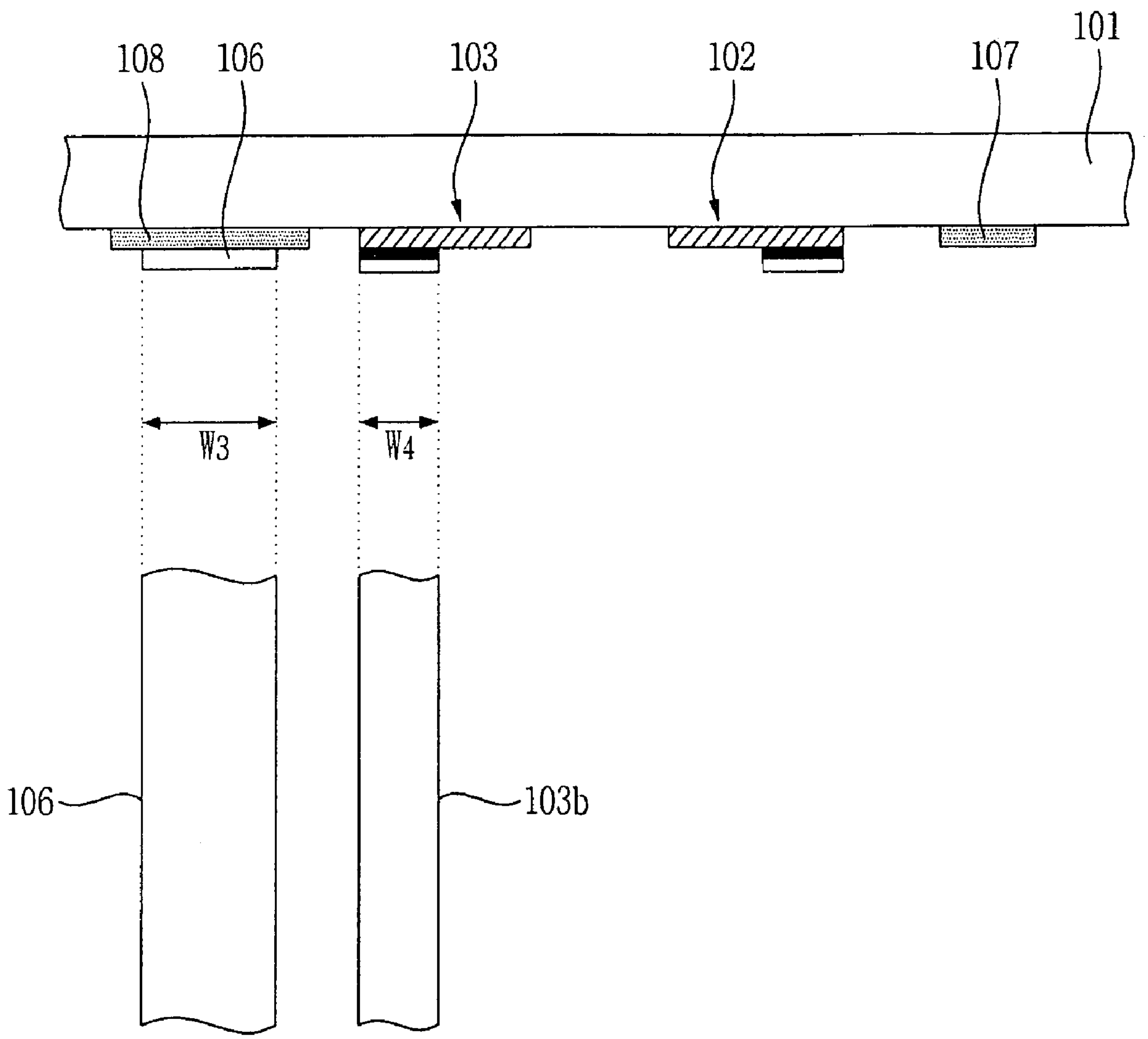


FIG. 18

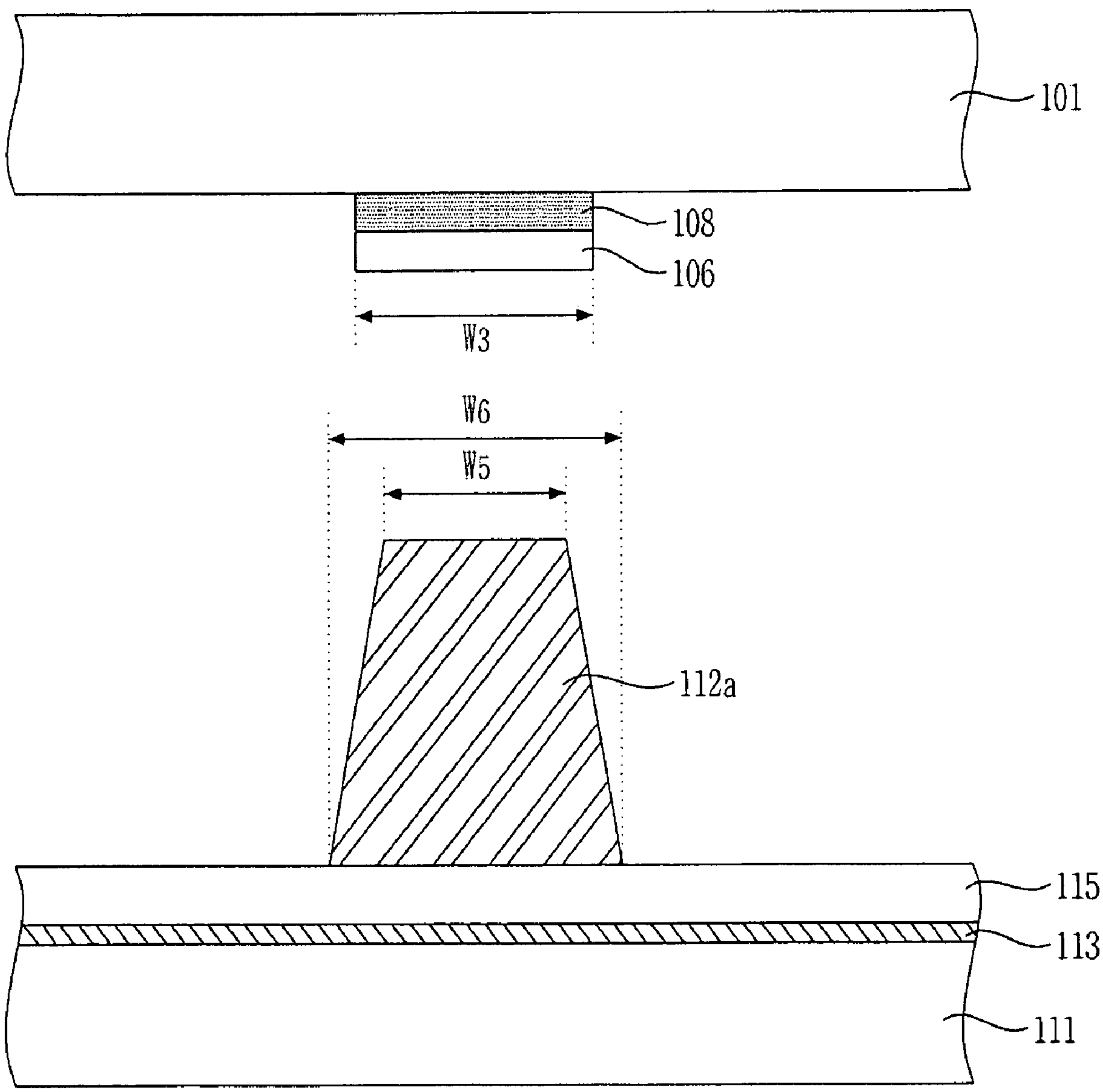


FIG. 19

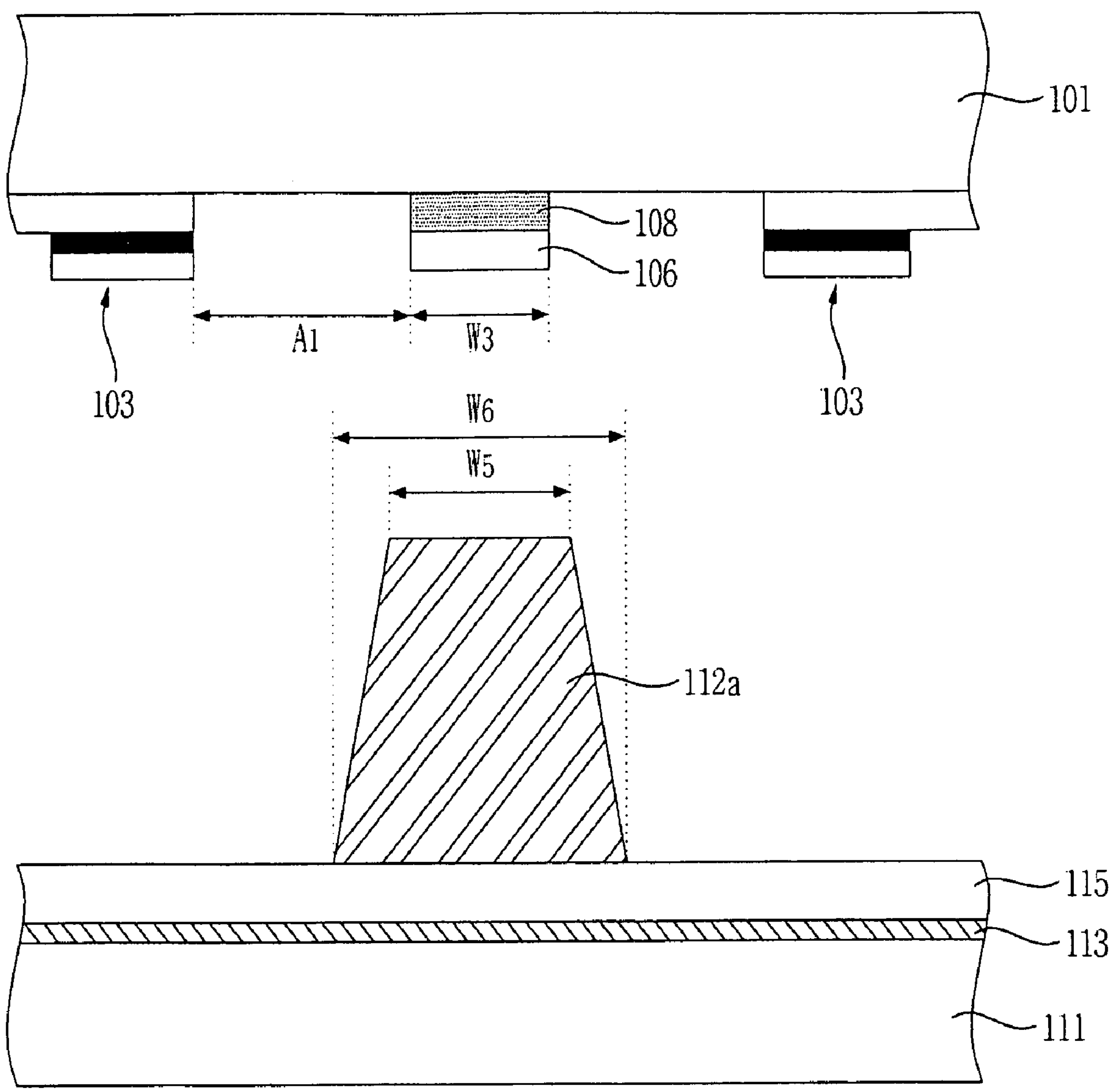


FIG. 20

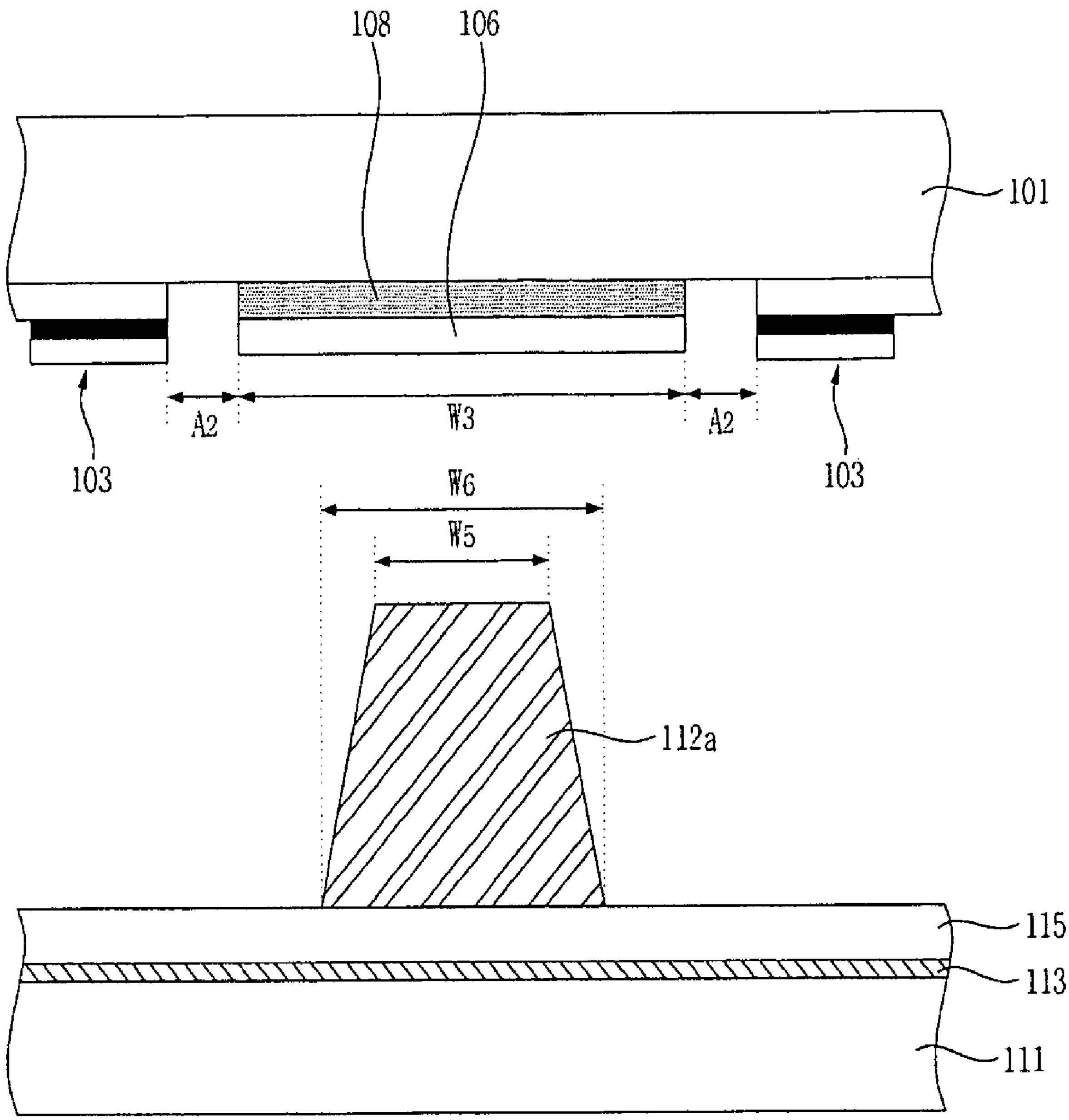


FIG. 21

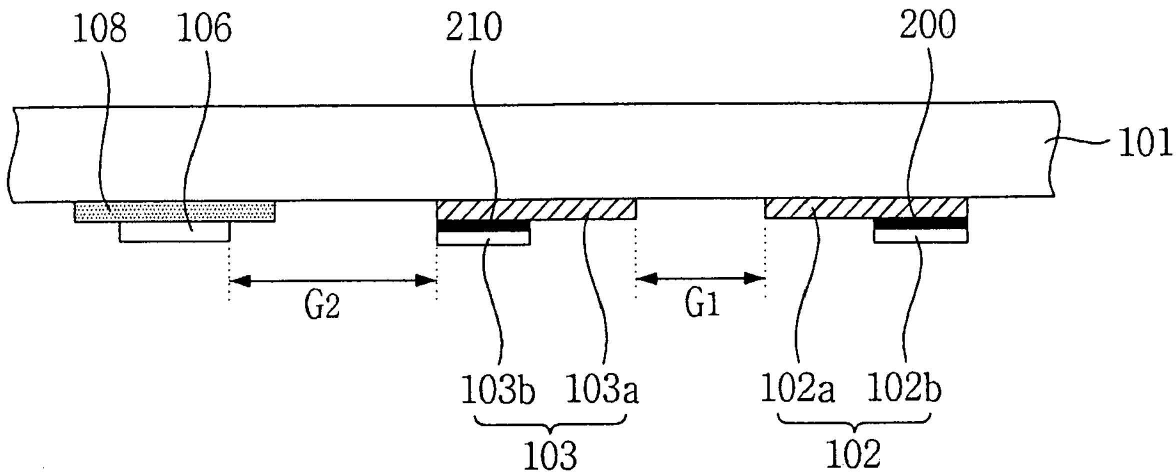


FIG. 22A

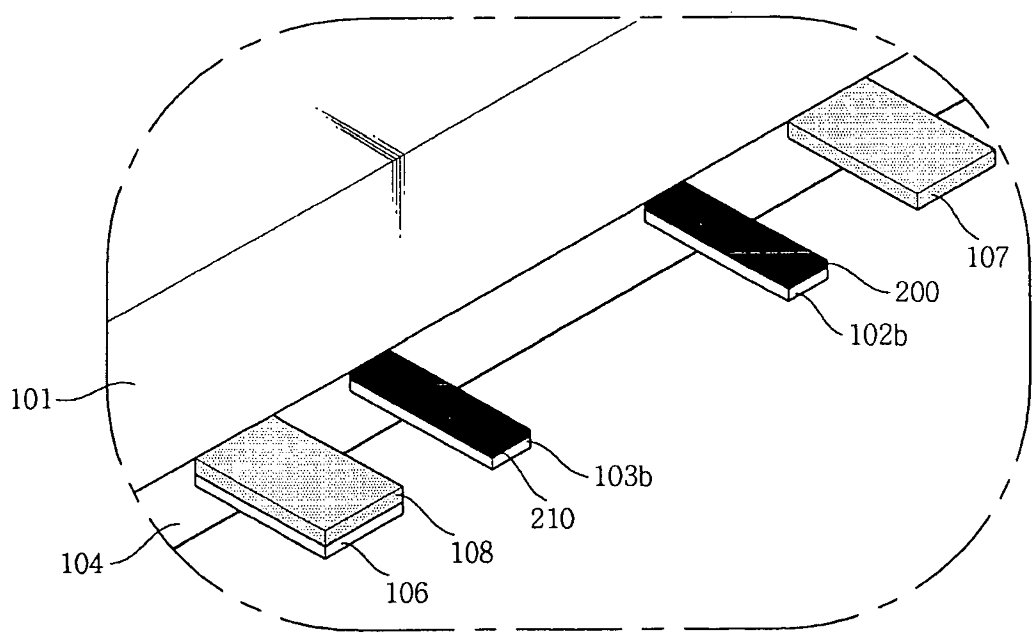
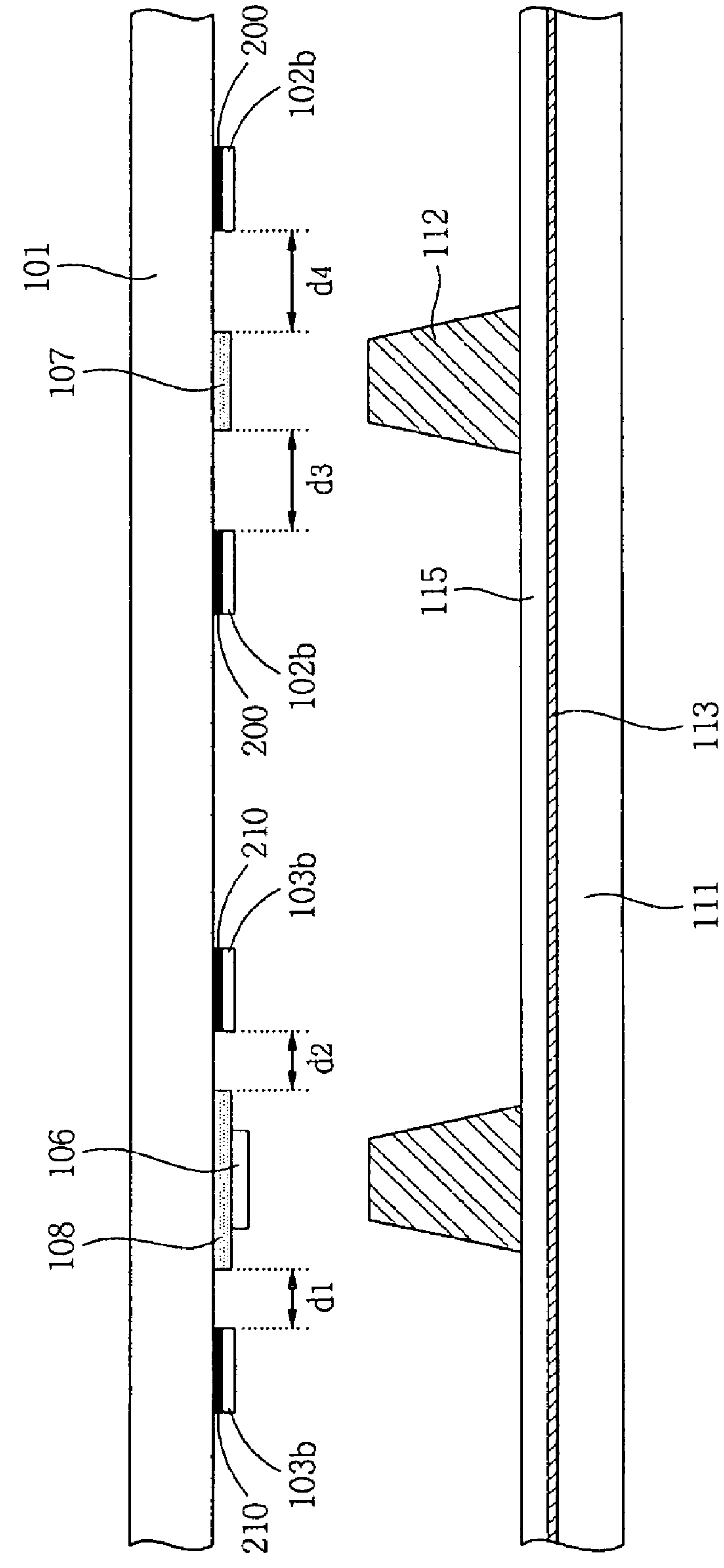


FIG. 22B


200
102b
101
d4
112
107
d3
115
102b
200
113
210
103b
111
d2
106
108
d1
103b
210

PLASMA DISPLAY PANEL

This application claims the benefit of Korean Patent Application No. 10-2008-0076850 filed on Aug. 6, 2008, the entire contents of which is hereby incorporated by reference.

BACKGROUND

1. Field

Embodiments relate to a plasma display panel.

2. Description of the Background Art

A plasma display panel includes a phosphor layer inside discharge cells partitioned by barrier ribs and a plurality of electrodes.

When driving signals are applied to the electrodes of the plasma display panel, a discharge occurs inside the discharge cells. More specifically, when the discharge occurs in the discharge cells by applying the driving signals to the electrodes, a discharge gas filled in the discharge cells generates vacuum ultraviolet rays, which thereby cause phosphors between the barrier ribs to emit visible light. An image is displayed on the screen of the plasma display panel using the visible light.

SUMMARY

In one aspect, a plasma display panel comprises a front substrate, scan electrodes and sustain electrodes that are positioned on the front substrate substantially parallel to each other, a rear substrate opposite the front substrate, a barrier rib on the rear substrate, a black layer opposite the barrier rib, the black layer being positioned on the front substrate substantially parallel to the scan electrode and the sustain electrode, the black layer including a first black layer between the two adjacent scan electrodes and a second black layer between the two adjacent sustain electrodes, and an auxiliary electrode on the second black layer.

In another aspect, a plasma display panel comprises a front substrate, scan electrodes and sustain electrodes that are positioned on the front substrate substantially parallel to each other, a rear substrate opposite the front substrate, a barrier rib on the rear substrate, a black layer opposite the barrier rib, the black layer being positioned on the front substrate substantially parallel to the scan electrode and the sustain electrode, the black layer including a first black layer between the two adjacent scan electrodes and a second black layer between the two adjacent sustain electrodes, a width of the second black layer being greater than a width of the first black layer, and an auxiliary electrode on the second black layer.

In still another aspect, a plasma display panel comprises a front substrate, scan electrodes and sustain electrodes that are positioned on the front substrate substantially parallel to each other, the scan electrodes and the sustain electrodes being bus electrodes, a rear substrate opposite the front substrate, a barrier rib on the rear substrate, a black layer opposite the barrier rib, the black layer being positioned on the front substrate substantially parallel to the scan electrode and the sustain electrode, the black layer including a first black layer between the two adjacent scan electrodes and a second black layer between the two adjacent sustain electrodes, a width of the second black layer being greater than a width of the first black layer, and an auxiliary electrode on the second black layer.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompany drawings, which are included to provide a further understanding of the invention and are incorporated

on and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention. In the drawings:

FIGS. **1** and **2** illustrate a structure of a plasma display panel according to an exemplary embodiment;

FIG. **3** illustrates an exemplary method of driving a plasma display panel;

FIGS. **4** and **5** illustrate in detail an auxiliary electrode;

FIGS. **6** to **8** illustrate widths of first and second black layers;

FIGS. **9** and **10** illustrate a location relationship between first and second black layers and scan and sustain electrodes;

FIGS. **11** to **15** illustrate an arrangement structure of a scan electrode and a sustain electrode;

FIG. **16** illustrates structures of first and second black layers;

FIG. **17** illustrates widths of an auxiliary electrode and a bus electrode;

FIGS. **18** to **20** illustrate an auxiliary electrode and a barrier rib;

FIG. **21** illustrates a distance between an auxiliary electrode and a scan electrode or a sustain electrode; and

FIGS. **22**A and **22**B illustrate a structure of a plasma display panel when a scan electrode and a sustain electrode each include a bus electrode without a transparent electrode.

DETAILED DESCRIPTION

Reference will now be made in detail embodiments of the invention examples of which are illustrated in the accompanying drawings.

FIGS. **1** and **2** illustrate a structure of a plasma display panel according to an exemplary embodiment.

As shown in FIG. **1**, a plasma display panel **100** may include a front substrate **101** on which a scan electrode **102** and a sustain electrode **103** are positioned substantially parallel to each other and a rear substrate **111** on which an address electrode **113** is positioned to cross the scan electrode **102** and the sustain electrode **103**.

An upper dielectric layer **104** may be formed on the scan electrode **102** and the sustain electrode **103** to limit a discharge current of the scan electrode **102** and the sustain electrode **103** and to provide insulation between the scan electrode **102** and the sustain electrode **103**.

A protective layer **105** may be formed on the upper dielectric layer **104** to facilitate discharge conditions. The protective layer **105** may be formed of a material having a high secondary electron emission coefficient, for example, magnesium oxide (MgO).

A lower dielectric layer **115** may be formed on the address electrode **113** to provide insulation between the address electrodes **113**.

Barrier ribs **112** of a stripe type, a well type, a delta type, a honeycomb type, etc. may be formed on the lower dielectric layer **115** to partition discharge spaces (i.e., discharge cells). Hence, a first discharge cell emitting red light, a second discharge cell emitting blue light, and a third discharge cell emitting green light, etc. may be formed between the front substrate **101** and the rear substrate **111**.

The barrier rib **112** may include first and second barrier ribs **112***a* and **112***b* crossing each other. Heights of the first and second barrier ribs **112***a* and **112***b* may be different from each other. The first barrier rib **112***a* may be parallel to the scan electrode **102** and the sustain electrode **103**, and the second barrier rib **112***b* may be parallel to the address electrode **113**.

The height of the first barrier rib **112***a* may be less than the height of the second barrier rib **112***b*. Hence, in an exhaust process and a process for infecting a discharge gas, an impurity gas in the panel **100** may be efficiently exhausted to the outside of the panel **100**, and the discharge gas may be uniformly injected. Each of the discharge cells partitioned by the barrier ribs **112** may be filled with the discharge gas.

A phosphor layer **114** may be formed inside the discharge cells to emit visible light for an image display during an address discharge. For example, first, second, and third phosphor layers that respectively generate red, blue, and green light may be formed inside the discharge cells.

FIG. **1** shows that the upper dielectric layer **104** and the lower dielectric layer **115** each have a single-layered structure. At least one of the upper dielectric layer **104** and the lower dielectric layer **115** may have a multi-layered structure.

While the address electrode **113** may have a substantially constant width or thickness, a width or thickness of the address electrode **113** inside the discharge cell may be different from a width or thickness of the address electrode **113** outside the discharge cell. For example, a width or thickness of the address electrode **113** inside the discharge cell may be greater than a width or thickness of the address electrode **113** outside the discharge cell.

An auxiliary electrode **106** may be positioned on the front substrate **101** parallel to the scan electrode **102** and the sustain electrode **103**.

As shown in FIG. **2**, first and second black layers **107** and **108** may be positioned on the front substrate **101** parallel to the scan electrode **102** and the sustain electrode **103**. The auxiliary electrode **106** may be positioned on the second black layer **108**.

The auxiliary electrode **106** may prevent charges from moving between the adjacent discharge cells to contribute to a prevention of crosstalk. The auxiliary electrode **106** may be formed of a material with excellent electrical conductivity, for example, silver (Ag), gold (Au), copper (Cu), aluminum (Al).

The upper dielectric layer **104** may be positioned on the second black layer **108** on which the auxiliary electrode **106** is positioned, the first black layer **107**, the scan electrode **102**, and the sustain electrode **103**. The scan electrode **102** and the sustain electrode **103** may include transparent electrodes **102***a* and **103***a* and bus electrodes **102***b* and **103***b*.

The transparent electrodes **102***a* and **103***a* may be formed of a transparent material, for example, indium-tin-oxide (ITO). The bus electrodes **102***b* and **103***b* may be formed of a material with electrical conductivity, such as Ag to improve electrical conductivity of the scan and sustain electrodes **102** and **103**. The bus electrodes **102***b* and **103***b* may be formed of the same material as the auxiliary electrode **106**.

A third black layer **200** may be positioned between the transparent electrode **102***a* and the bus electrode **102***b* of the scan electrode **102**, and a fourth black layer **210** may be positioned between the transparent electrode **103***a* and the bus electrode **103***b* of the sustain electrode **103**.

When the first, second, third, and fourth black layers **107**, **108**, **200**, and **210** are positioned as above, a reflection of light coming from the outside may be prevented. Contrast characteristics of a displayed image may be improved.

It may be preferable that a width of the auxiliary electrode **106** may be less than or substantially equal to a width of the second black layer **108**, so as to improve the contrast characteristics by preventing light from the outside from being reflected by the auxiliary electrode **106**.

The auxiliary electrode **106** and the first and second black layers **107** and **108** may be simultaneously fired, so as to reduce time required in a manufacturing process and reduce the manufacturing cost. The auxiliary electrode **106**, the first, second, third, and fourth black layers **107**, **108**, **200**, and **210**, and the bus electrodes **102***b* and **103***b* may be simultaneously fired.

FIG. **3** illustrates an exemplary method of driving the plasma display panel.

As shown in FIG. **3**, a rising signal RS and a falling signal FS may be supplied to the scan electrode Y during a reset period RP for initialization of at least one subfield of a plurality of subfields of a frame.

More specifically, the rising signal RS may be supplied to the scan electrode Y during a setup period SU of the reset period RP, and the falling signal FS may be supplied to the scan electrode Y during a set-down period SD following the setup period SU. The rising signal RS may generate a weak dark discharge (i.e., a setup discharge) inside the discharge cells. Hence, the remaining wall charges may be uniformly distributed inside the discharge cells. The falling signal FS may generate a weak erase discharge (i.e., a set-down discharge) inside the discharge cells. Hence, the remaining wall charges may be uniformly distributed inside the discharge cells to the extent that an address discharge occurs stably.

During an address period AP following the reset period RP, a scan bias signal Vsc having a voltage greater than a minimum voltage of the falling signal FS may be supplied to the scan electrode Y. A scan signal Scan falling from the scan bias signal Vsc may be supplied to the scan electrode Y during the address period AP.

A pulse width of a scan signal supplied to the scan electrode during an address period of at least one subfield of a frame may be different from pulse widths of scan signals supplied during address periods of other subfields of the frame. A pulse width of a scan signal in a subfield may be greater than a pulse width of a scan signal in a next subfield. For example, a pulse width of the scan signal may be gradually reduced in the order of 2.6 μs, 2.3 μs, 2.1 μs, 1.9 μs, etc., or may be reduced in the order of 2.6 μs, 2.3 μs, 2.3 μs, 2.1 μs, . . . , 1.9 μs, 1.9 μs, etc. in the successively arranged subfields.

When the scan signal Scan is supplied to the scan electrode Y, a data signal Data corresponding to the scan signal Scan may be supplied to the address electrode X. As the voltage difference between the scan signal Scan and the data signal Data is added to a wall voltage by the wall charges produced during the reset period RP, an address discharge may occur inside the discharge cells to which the data signal Data is supplied.

During a sustain period SP following the address period AP, a sustain signal SUS may be supplied to at least one of the scan electrode Y or the sustain electrode Z. FIG. **3** shows that the sustain signals SUS are alternately supplied to the scan electrode Y and the sustain electrode Z. As the wall voltage inside the discharge cells selected by performing the address discharge is added to a sustain voltage of the sustain signal SUS, every time the sustain signal SUS is supplied, a sustain discharge (i.e., a display discharge) may occur between the scan electrode Y and the sustain electrode Z.

FIGS. **4** and **5** illustrate in detail the auxiliary electrode.

As shown in FIG. **4**, both ends of the auxiliary electrode **106** may be positioned inside the panel. In other words, the auxiliary electrode **106** is not electrically connected to an external device and is in a floating state. In this case, a voltage may be produced in the auxiliary electrode **106** because of a coupling phenomenon resulting from a voltage of the scan electrode **102** or the sustain electrode **103** adjacent to the auxiliary electrode **106**. Therefore, a voltage of the auxiliary electrode **106** may be determined by the voltage of the scan electrode or the sustain electrode **103** adjacent to the auxiliary electrode **106**.

Unlike a description of FIG. **4**, a predetermined voltage may be applied to the auxiliary electrode **106**. For example, the auxiliary electrode **106** may include a pad portion (not shown) and may be connected to an external ground through the pad portion. Hence, the auxiliary electrode **106** may be held at a ground level voltage. Alternately, the auxiliary electrode **106** may be connected to an external driver through the pad portion and may be held at a positive voltage that is greater than the ground level voltage and less than the sustain voltage of the sustain signal SUS.

As above, the auxiliary electrode **106** may prevent charges from moving between the adjacent discharge cells to contribute to the prevention of crosstalk.

FIG. **5** shows an upper discharge cell **300** called as a first discharge cell and a lower discharge cell **310** called as a second discharge cell. It is assumed that the first discharge cell **300** is an on-cell in which a sustain discharge occurs and the second discharge cell **310** is an off-cell in which a sustain discharge does not occur.

If the auxiliary electrode is not formed as shown in (a) of FIG. **5**, charges **320** resulting from the sustain discharge generated in the first discharge cell **300** may easily move to the second discharge cell **310** adjacent to the first discharge cell **300**. Hence, the charges **320** may generate a sustain discharge in the second discharge cell **310** in which the sustain discharge does not have to occur. The image quality may be reduced because of the crosstalk phenomenon.

On the other hand, if the auxiliary electrode **106** is formed as shown in (b) of FIG. **5**, the auxiliary electrode **106** may prevent charges **320** generated in the first discharge cell **300** from moving to the second discharge cell **310**. Hence, the crosstalk phenomenon may be prevented.

It may be advantageous in an exhaust process and a process for injecting a discharge gas that the height of the first barrier rib **112***a* parallel to the scan electrode **102** and the sustain electrode **103** is less than the height of the second barrier rib **112***b* parallel to the address electrode **113**. However, because charges easily move between the adjacent discharge cells, crosstalk may increase. Accordingly, when the height of the first barrier rib **112***a* is less than the height of the second barrier rib **112***b*, it may be preferable that the auxiliary electrode **106** is provided.

FIGS. **6** to **8** illustrate widths of first and second black layers.

As shown in FIG. **6**, a width W**1** of the second black layer **108** may be greater than a width W**3** of the auxiliary electrode **106** on the second black layer **108**. In this case, light coming from the outside of the panel may be prevented from being reflected by the auxiliary electrode **106**, and thus the contrast characteristics may be improved.

Further, the width W**1** of the second black layer **108** may be substantially equal to the width W**3** of the auxiliary electrode **106**. In this case, the contrast characteristics may be improved.

The widths W**1**, W**2**, and W**3** of the second black layer **108**, the first black layer **107**, and the auxiliary electrode **106** are widths measured in a direction crossing the scan electrode **102** and the sustain electrode **103**.

The width W**1** of the second black layer **108** may be greater than the width W**2** of the first black layer **107**. This reason will be described with reference to FIGS. **7** and **8**.

FIG. **7** shows the front substrate **101** in which the auxiliary electrode is omitted. In the front substrate **101** having the above-described structure, a sustain discharge starts to occur between the scan electrode **102** and the sustain electrode **103**, and then the sustain discharge may be somewhat uniformly diffused. As a result, light may be somewhat uniformly generated inside the discharge cells.

On the other hand, FIG. **8** shows the front substrate **101** on which the auxiliary electrode **106** is formed. Because the auxiliary electrode **106** has electrical conductivity, a sustain discharge starting to occur between the scan electrode **102** and the sustain electrode **103** may be attracted to the auxiliary electrode **106**. As a result, light may be non-uniformly generated inside the discharge cells.

As shown in FIG. **8**, because the sustain discharge is attracted to the sustain electrode **103** because of the auxiliary electrode **106**, an amount of light emitted to a portion P**1** between the sustain electrode **103** and the auxiliary electrode **106** may be more than an amount of light emitted to a portion P**2** between the scan electrode **102** and the auxiliary electrode **106**. Hence, the image quality of the panel may worsen. For example, a viewer may perceive that a luminance sharply changes depending on a direction in which the viewer watches the screen of the panel. Further, the viewer may perceive that the luminance is excessively reduced in a specific direction. Consequently, the viewer may perceive that the image quality of the panel worsens because of the non-uniformity of light.

When the width W**1** of the second black layer **108** on which the auxiliary electrode **106** is positioned is greater than the width W**2** of the first black layer **107** on which the auxiliary electrode **106** is not positioned as shown in FIG. **6**, an amount of light emitted to the portion P**1** may be substantially equal to an amount of light emitted to the portion P**2** even if the light is non-uniformly generated as shown in FIG. **8**. Therefore, a reduction in the image quality may be prevented. It is preferable that the width W**1** of the second black layer **108** is greater than the width W**2** of the first black layer **107**.

An amount of light may unnecessarily increase in a portion in which the auxiliary electrode **106** is positioned. As a result, the contrast characteristics may be reduced. However, light may be prevented from unnecessarily increasing in the portion in which the auxiliary electrode **106** is positioned by allowing the width W**1** of the second black layer **108** overlapping the auxiliary electrode **106** to be greater than the width W**2** of the first black layer **107**. As a result, a reduction in the contrast characteristics may be prevented.

FIGS. **9** and **10** illustrate a location relationship between the first and second black layers and the scan and sustain electrodes.

As shown in FIG. **9**, the first and second black layers **107** and **108** are positioned on the front substrate **101** parallel to each other with at least one scan electrode **102** and at least one sustain electrode **103** interposed between the first and second black layers **107** and **108**.

The first and second black layers **107** and **108** may be spaced apart from the scan and sustain electrodes **102** and **103** adjacent to the first and second black layers **107** and **108**. For example, FIG. **9** shows that the second black layer **108** is spaced apart from the two sustain electrodes **103** adjacent to the second black layer **108** at distances d**1** and d**2** and the first black layer **107** is spaced apart from the two scan electrodes **102** adjacent to the first black layer **107** at distances d**3** and d**4**.

Because the width of the second black layer **108** is greater than the width of the first black layer **107**, the distances d**1** and d**2** between the second black layer **108** and the sustain electrodes **103** may be shorter than the distances d**3** and d**4** between the first black layer **107** and the scan electrodes **102**. The distances d**1** and d**2** may be substantially equal to or different from each other, and the distances d3 and d4 may be substantially equal to or different from each other.

The first black layer **107** may be spaced apart from the scan and sustain electrodes **102** and **103** adjacent to the first black layer **107**, and the second black layer **108** may be poisoned to be connected to at least one scan electrode **102** or at least one sustain electrode **103** adjacent to the second black layer **108**. For example, FIG. **10** shows the second black layer **108** connected to the two sustain electrodes **103** adjacent to the second black layer **108**. In this case, the second black layer **108** and the fourth black layers **210** of the two sustain electrodes **103** may form one common black layer. In FIG. **10**, the width of the second black layer **108** is greater than the width of the first black layer **107**.

FIGS. **11** to **15** illustrate an arrangement structure of the scan electrode and the sustain electrode. The illustration of the first and second black layers is omitted in FIGS. **11** to **15**.

The two scan electrodes may be adjacently positioned, and the two sustain electrodes may be adjacently positioned. For example, FIG. **11** shows two adjacent scan electrodes Y**1** and Y**2**, two adjacent scan electrodes Y**3** and Y**4**, and two adjacent sustain electrodes Z**2** and Z**3**.

In the above electrode arrangement, it may be preferable that the auxiliary electrode **106** is positioned between the two adjacent sustain electrodes. Namely, the second black layer is positioned between the two adjacent sustain electrodes, and the auxiliary electrode **106** is positioned on the second black layer.

In the above electrode arrangement, the drive efficiency may be improved by reducing a capacitance between the two adjacent scan electrodes and a capacitance between the two adjacent sustain electrodes. Further, the crosstalk may be reduced by reducing a voltage difference between the two adjacent scan electrodes and a voltage difference between the two adjacent sustain electrodes during a discharge.

FIG. **12** shows that the scan electrodes Y**1**, Y**2**, and Y**3** and the sustain electrodes Z**1**, Z**2**, and Z**3** are alternately positioned. In FIG. **12**, it is assumed that sustain signals having a voltage of 180V are supplied to the scan electrodes Y**1**, Y**2**, and Y**3** and 0V is supplied to the sustain electrodes Z**1**, Z**2**, and Z**3**.

In this case, a movement of charges **1100** between the adjacent discharge cells may briskly occurs. For example, if a sustain discharge occurs between the scan electrode Y**2** and the sustain electrode Z**2** as shown in FIG. **12**, a voltage difference of 180V is caused between the sustain electrode Z**2** and the scan electrode Y**3** and between the scan electrode Y**2** and the sustain electrode Z**1**. The charges **1100** resulting from the sustain discharge generated between the scan electrode Y**2** and the sustain electrode Z**2** are attracted to the scan electrode Y**3** or the sustain electrode Z**1** and move to the discharge cell adjacent to the discharge cell where the sustain discharge occurs. As a result, a sustain discharge may occur between the scan electrode Y**1** and the sustain electrode Z**1** or between the scan electrode Y**3** and the sustain electrode Z**3**. Namely, the crosstalk phenomenon may frequently occur.

On the other hand, as shown in FIG. **13**, when two scan electrodes are adjacently positioned and two sustain electrodes are adjacently positioned, a voltage difference of 0V is caused between the sustain electrodes Z**1** and Z**2** and the scan electrodes Y**2** and Y**3** even if sustain signals having a voltage of 180V are supplied to the scan electrodes and 0V is supplied to the sustain electrodes. Because a voltage difference is not caused between the adjacent discharge cells, a movement of charges **1100** is suppressed. Hence, the crosstalk may be reduced.

A reason why the auxiliary electrode **106** is positioned between the two adjacent sustain electrodes will be described with reference to FIGS. **14** and **15**.

FIG. **14** shows the auxiliary electrode between the two adjacent scan electrodes. More specifically, a first auxiliary electrode **106***a* is positioned between the two scan electrodes Y**1** and Y**2**, and a second auxiliary electrode **106***b* is positioned between the two scan electrodes Y**3** and Y**4**.

FIG. **15** illustrates an exemplary operation of the panel during an address period in the electrode structure shown in FIG. **14**. The first and second auxiliary electrodes **106***a* and **106***b* are considered to be floated.

For example, when a first scan signal Scan**1** is supplied to the scan electrode Y**1**, an address discharge may occur by a voltage difference between a data signal supplied to the address electrode X**1** and the first scan signal Scan**1**. Further, when a second scan signal Scan**2** is supplied to the scan electrode Y**2**, an address discharge may occur by a voltage difference between the data signal supplied to the address electrode X**1** and the second scan signal Scan**2**.

When the address discharge occurs by the first scan signal Scan**1** and the data signal, a first falling signal fs**1** may be produced in the first auxiliary electrode **106***a* by a voltage of the first scan signal Scan**1**. A voltage of the first falling signal fs**1** affects the scan electrode Y**2** adjacent to the first auxiliary electrode **106***a*, and thus a distribution state of wall charges on the scan electrode Y**2** may be non-uniform. Hence, the address discharge generated by the second scan signal Scan**2** and the data signal may be unstable. Even if the voltage of the first falling signal fs**1** has a excessively great value, an erroneous discharge may occur between the scan electrode Y**2** or the first auxiliary electrode **106***a* and the address electrode when the address discharge occurs by the first scan signal Scan**1** and the data signal.

As above, when the auxiliary electrode is positioned between two scan electrodes, the address discharge may unstably occur or the erroneous discharge may occur. Therefore, it is preferable that the auxiliary electrode is positioned between two sustain electrodes as shown in FIG. **11**.

FIG. **16** illustrates structures of the first and second black layers.

At least one of the first and second black layers **107** and **108** may include first and second portions each having a different width. For example, FIG. **16** shows that the first and second black layers **107** and **108** each include a first portion having a first width S**1** and a second portion having a first width S**2**.

Because the second black layer **108** includes the first portion **108***a* and the second portion **108***b* as shown in FIG. **16**, the auxiliary electrode (not shown) on the second black layer **108** may include first and second portions each having a different width.

The second portions of the first and second black layers **107** and **108** may be positioned at a crossing of the first and second barrier ribs **112***a* and **112***b*.

As above, when at least one of the first and second black layers **107** and **108** includes the first and second portions, a black area may increase. Hence, the contrast characteristics may be improved. Further, when the second portion of the auxiliary electrode is positioned at the crossing of the first and second barrier ribs **112***a* and **112***b*, a black area may increase while a reduction in an aperture ratio is prevented. Hence, the contrast characteristics may be further improved.

FIG. **17** illustrates widths of the auxiliary electrode and the bus electrode.

As shown in FIG. **17**, a width W**3** of the auxiliary electrode **106** may be greater than a width W**4** of the bus electrode **103***b*. The width W**3** of the auxiliary electrode **106** may be greater than a width of the bus electrode of the scan electrode **102** as well as the bus electrode **103***b* of the sustain electrode **103**.

As above, when the width W**3** of the auxiliary electrode **106** is greater than the width W**4** of the bus electrode **103***b*, a charge capacity of the auxiliary electrode **106** may sufficiently increase. Therefore, charge may be prevented from moving between the adjacent discharge cells, and the crosstalk may be reduced.

FIGS. **18** to **20** illustrate the auxiliary electrode and the barrier rib.

As shown in FIG. **18**, the width W**3** of the auxiliary electrode **106** may be greater than an upper width W**5** of the first barrier rib **112***a* and less than a lower width W**6** of the first barrier rib **112***a*. Further, the width W**3** of the auxiliary electrode **106** may be substantially equal to the upper width W**5** or the lower width W**6** of the first barrier rib **112***a*.

When the width W**3** of the auxiliary electrode **106** is equal to or greater than the upper width W**5** of the first barrier rib **112***a* and is equal to or less than the lower width W**6** of the first barrier rib **112***a*, electrical short circuit between the auxiliary electrode **106** and the scan electrode **102** or the sustain electrode **103** adjacent to the auxiliary electrode **106** may be prevented while charge are prevented from moving between the adjacent discharge cells.

As shown in FIG. **19**, when the width W**3** of the auxiliary electrode **106** is less than the upper width W**5** of the first barrier rib **112***a*, the charge capacity of the auxiliary electrode **106** may be reduced because of the narrow auxiliary electrode **106**. Hence, it may be difficult to prevent the crosstalk. Further, a distance A**1** between the auxiliary electrode **106** and the scan electrode **102** or the sustain electrode **103** adjacent to the auxiliary electrode **106** may excessively increase. Hence, an amount of light reflected by the first barrier rib **112***a* may increase, and the contrast characteristics may be reduced.

As shown in FIG. **20**, when the width W**3** of the auxiliary electrode **106** is greater than the lower width W**6** of the first barrier rib **112***a*, a distance A**2** between the auxiliary electrode **106** and the scan electrode **102** or the sustain electrode **103** adjacent to the auxiliary electrode **106** may excessively decrease because of the wide auxiliary electrode **106**. In this case, electrical short circuit may occur between the auxiliary electrode **106** and the scan electrode **102** or the sustain electrode **103** adjacent to the auxiliary electrode **106**, thereby unstably generating a discharge.

Considering this, it may be preferable that the width W**3** of the auxiliary electrode **106** is equal to or greater than the upper width W**5** of the first barrier rib **112***a* and is equal to or less than the lower width W**6** of the first barrier rib **112***a*.

FIG. **21** illustrates the scan electrode, the sustain electrode, and the auxiliary electrode.

As shown in FIG. **21**, a distance G**2** between the auxiliary electrode **106** and the scan electrode **102** or the sustain electrode **103** may be greater than a distance G**1** between the scan electrode **102** and the sustain electrode **103**. In this case, a firing voltage between the scan electrode **102** and the sustain electrode **103** may be prevented from excessively rising, and a reduction in the drive efficiency may be prevented. Further, a discharge generated between the scan electrode **102** and the sustain electrode **103** may be prevented from being excessively attracted to the auxiliary electrode **106**.

FIGS. **22**A and **22**B illustrate a structure of a plasma display panel when the scan electrode **102** and the sustain electrode **103** each include only the bus electrodes **102***b* and **103***b* without the transparent electrode.

As shown in FIG. **22**A, each of the scan electrode **102** and the sustain electrode **103** may include the bus electrodes **102***b* and **103***b* without the transparent electrode.

The scan electrode **102** and the sustain electrode **103** including the bus electrodes **102***b* and **103***b* may be formed of a material with excellent electrical conductivity that is easy to mold, for example, silver (Ag), gold (Au), copper (Cu), aluminum (Al).

As shown in FIG. **22**B, a width W**1** of the second black layer **108** may be greater than a width W**2** of the first black layer **107**. This reason is the same as that described in FIGS. **7** and **8**. The first black layer **107** is positioned between the two adjacent scan electrodes to be spaced apart from the two scan electrodes. The second black layer **108** is positioned between the two adjacent sustain electrodes to be spaced apart from the two sustain electrodes.

The above-described description may be applied to the plasma display panel illustrated in FIGS. **22**A and **22**B in which the transparent electrode is omitted.

Any reference in this specification to "one embodiment," "an embodiment," "example embodiment," etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments.

Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

1. A plasma display panel comprising:

a front substrate;

scan electrodes and sustain electrodes that are positioned on the front substrate substantially parallel to each other;

a rear substrate opposite the front substrate;

a barrier rib on the rear substrate;

a black layer opposite the barrier rib, the black layer being positioned on the front substrate substantially parallel to the scan electrode and the sustain electrode, the black layer including a first black layer between two adjacent scan electrodes and a second black layer between two adjacent sustain electrodes; and

an auxiliary electrode on the second black layer.

2. The plasma display panel of claim **1**, wherein a width of the second black layer is greater than a width of the first black layer.

3. The plasma display panel of claim **1**, wherein the first black layer is spaced apart from the scan electrodes adjacent to the first black layer, and the second black layer is connected to at least one sustain electrode adjacent to the second black layer.

4. The plasma display panel of claim **1**, wherein at least one of the first black layer and the second black layer includes a first portion having a first width and a second portion having a second width greater than the first width.

5. The plasma display panel of claim 4, wherein the barrier rib includes a first barrier rib substantially parallel to the scan electrode and the sustain electrode and a second barrier rib crossing the first barrier rib,

wherein the second portion is positioned in a crossing of the first barrier rib and the second barrier rib.

6. The plasma display panel of claim 1, wherein a width of the auxiliary electrode is equal to or less than a width of the second black layer.

7. The plasma display panel of claim 1, wherein the scan electrode and the sustain electrode each include a transparent electrode and a bus electrode on the transparent electrode,

wherein a width of the auxiliary electrode is equal to or greater than a width of the bus electrode.

8. The plasma display panel of claim 1, wherein a shortest distance between the auxiliary electrode and the sustain electrode is greater than a shortest distance between the scan electrode and the sustain electrode in a discharge cell.

9. The plasma display panel of claim 1, wherein the auxiliary electrode is floated.

10. The plasma display panel of claim 1, wherein the barrier rib includes a first barrier rib substantially parallel to the scan electrode and the sustain electrode and a second barrier rib crossing the first barrier rib,

wherein a height of the first barrier rib is less than a height of the second barrier rib.

11. The plasma display panel of claim 1, wherein a shortest distance between the second black layer and the sustain electrode is shorter than a shortest distance between the first black layer and the scan electrode.

12. A plasma display panel comprising:

a front substrate;

scan electrodes and sustain electrodes that are positioned on the front substrate substantially parallel to each other;

a rear substrate opposite the front substrate;

a barrier rib on the rear substrate;

a black layer opposite the barrier rib, the black layer being positioned on the front substrate substantially parallel to the scan electrode and the sustain electrode, the black layer including a first black layer between two adjacent scan electrodes and a second black layer between two adjacent sustain electrodes, a width of the second black layer being greater than a width of the first black layer; and

an auxiliary electrode on the second black layer.

13. The plasma display panel of claim 12, wherein the first black layer is spaced apart from the scan electrodes adjacent to the first black layer, and the second black layer is connected to at least one sustain electrode adjacent to the second black layer.

14. The plasma display panel of claim 12, wherein a shortest distance between the auxiliary electrode and the sustain electrode is greater than a shortest distance between the scan electrode and the sustain electrode in a discharge cell.

15. The plasma display panel of claim 12, wherein the auxiliary electrode is floated.

16. The plasma display panel of claim 12, wherein a shortest distance between the second black layer and the sustain electrode is shorter than a shortest distance between the first black layer and the scan electrode.

17. A plasma display panel comprising:

a front substrate;

scan electrodes and sustain electrodes that are positioned on the front substrate substantially parallel to each other, the scan electrodes and the sustain electrodes being bus electrodes;

a rear substrate opposite the front substrate;

a barrier rib on the rear substrate;

a black layer opposite the barrier rib, the black layer being positioned on the front substrate substantially parallel to the scan electrode and the sustain electrode, the black layer including a first black layer between two adjacent scan electrodes and a second black layer between two adjacent sustain electrodes, a width of the second black layer being greater than a width of the first black layer; and

an auxiliary electrode on the second black layer.

18. The plasma display panel of claim 17, wherein the first black layer is spaced apart from the scan electrodes adjacent to the first black layer, and the second black layer is connected to at least one sustain electrode adjacent to the second black layer.

19. The plasma display panel of claim 17, wherein a shortest distance between the auxiliary electrode and the sustain electrode is greater than a shortest distance between the scan electrode and the sustain electrode in a discharge cell.

20. The plasma display panel of claim 17, wherein the auxiliary electrode is floated.

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